Affordance competition in dialogue: the case of syntactic universals

Anonymous ACL submission

Abstract

In this paper, we explore the idea that independently developed Dynamic Syntax accounts of dialogue and interaction fit well within the general approach of radical embodied and enactive accounts of cognition (REEC). Taking this approach enables a rethinking of the grounding of linguistic universal constraints, specifically tree structure restrictions, as the outcome of affordance competition, a general REEC sociocognitive mechanism underpinning action selection. In light of this subsumption, we argue that such an approach opens up a whole new area of language-related dynamic systems research.

Gregoromichelaki et al. (2019) claim that, in virtue of modelling natural languages (NLs) as actions licensing context to context transitions, Dynamic Syntax (DS) fits well within radical embodied and enactive accounts of cognition (REEC) (Bruineberg et al., 2018; Paolo et al., 2018). However, major trends within REEC still remain underdeveloped with respect to the fine-grained details of NL-related issues, a lacuna which Gregoromichelaki et al. argue that DS naturally covers. This paper addresses a putative counterexample to the REEC general claim of the dispensability of standard representational assumptions and the primacy of action. It concerns a robust structural constraint said to hold of all NLs (Kempson et al., 2016 a.o). We argue that such a restriction does not necessitate a representational explanation and can be seen instead as grounded in a combination of socio-cognitive constraints and general properties of dynamical systems.

1 Syntax and universals

Dynamic Syntax, as set out in Kempson et al. (2001); Cann et al. (2005) and much other work since, is a grammar architecture whose core basis is incremental integration of the contribution of word sequences within a surrounding landscape of affordances. Affordances, under this perspective, are relations between possibilities for action provided by the environment (including the social milieu) and abilities available in a 'form of life' (Rietveld and Kiverstein, 2014 a.o.). Within this view, we take the grammar as an integral part of the sociocognitive environment into which humans are enculturated via natural dialogue and interaction. Thus the grammar is not seen as qualitatively different to other constraints influencing environment-engaging behaviour patterns of individuals and groups in the achievement of their aims and goals. It is of course possible to reify these processes of linguistic engagement with the world and assign them abstract structure formulated in representational terms, like the standard grammatical models postulated by linguists. Indeed, folk theories of language and thought (at least in some societies) undeniably possess such conceptions of what language is, and we do not doubt that such conceptualisations affect the way people act with respect to their linguistic behaviour. However, we believe that such conceptions are neither basic, nor universal, instead, they constitute further affordances available in particular social groups for engaging with the available resources and constraining relevant action possibilities.

Grammar – which for us includes what are standardly distinguished as syntax and semantics/pragmatics – constrains human (inter)action by providing a source of normativity, of what is right or wrong, of what makes sense or not, relative to particular social practices. For this reason, grammar is not a construct encapsulated within an individual brain or mind. Following Wittgenstein's well-known arguments against the

existence of "private languages" and an interpretative conception of rule-following, we assume that normativity constraints apply within a public domain of expression (even in cases where we privately rehearse responses to a simulation of such interactional challenges in the public domain). In the REEC affordance literature, a distinction is made between individual *abilities* which are non-representational capacities allowing individuals to perceive and pick up what opportunities and restrictions are available in their sociomaterial environment and *affordances* which exist within practices or 'forms of life' independently of any particular individual agent. Grammars, in our view, operate at the level of regulating actions in practices, both linguistic and non-verbal, and, for this reason, are part of the public landscape of affordances available to interacting agents in each particular case of engagement with the environment. Whether agents interact solely with the physical environment or with other agents, their actions (which constitute their conceptualisations) are enabled and restricted by normative constraints that are imposed by the various cultural groups they inhabit or wish to associate with. Due to membership in various such cultural groups, in each occasion of engagement, agents' actions in turn "enact" and hence modify or enrich the normative constraints available in the practice. Words, both as forms and meanings, and syntactic constructions are established patterns of actions that can be fitted in across various 'language games' to enact the nature of the current activity subject to normative judgements emanating from sources outside the acting agent. This results in a system constantly in flux but with enough emergent stability on each particular occasion to underpin agent coordination in the service of various purposes.

In accordance with these assumptions, the DS syntactic engine, including the lexicon, is articulated in terms of goal-driven actions (see also (van Benthem, 2011) accomplished either by giving rise to expectations of further action opportunities, by exploiting contextual resources, or by being abandoned as unviable in view of more competitive alternatives. Thus words, syntax, and morphology are all modelled as affordances, opportunities for (inter-)action, produced and recognised by interlocutors to perform step-by-step coordinated mappings from perceivable stimuli (phonological strings) to concept-constituting action patterns (routines, *macros*) or vice-versa (Gregoromichelaki et al., 2019).

The substance of the DS framework is given by a specialised dynamic modal logic (PDL, Propositional Dynamic Logic) whose state-transition language describes a process of gradual unfolding of a diagrammatically laid out relational structure modelling the landscape of salient affordances as a Directed Acyclic Graph (DAG). DAG nodes are in turn structured states modelling potential interpretations/productions. Interpretation or production relies on the process of potential traversal and gradual enrichment of local graph structures in the form of trees. Such traversals are possible by means of specialised modal operators that follow paths restricted to characterisations of (partial) tree structures. The latter are models of sets of constraints articulated within the logic of finite trees (LOFT, Blackburn and Meyer-Viol, 1994). Each node of a tree-structure model is in turn inhabited by graphs resembling feature structures whose attributes are modelled by modal operators bearing linguistically relevant labels like type, $\langle Ty \rangle$, treenode address, $\langle Tn \rangle$, and $\langle Fo \rangle$ for content. In current versions of DS, content values are Record Types (henceforth RT) of Type Theory with Records (TTR, Cooper and Ginzburg, 2015) under construction whose inherent underspecification fits well the potential for indefinite enrichment across various dimensions (Eshghi et al., 2013; Hough, 2015; Purver et al., 2011). RTs (standing for "concepts") can in turn be conceived as mini-grammars of the DS kind articulating affordances for engagement with aspects of the environment (Gregoromichelaki et al., 2019), or potential for interaction with others (Eshghi et al., 2017; Eshghi and Lemon, 2014). Alternatively, Sadrzadeh et al. (2018) show how combining a Vector Space Semantics methodology with DS can model incremental construction of ad hoc concepts to resolve issues of ambiguity and underspecification.

In both these approaches, DAGs map out the potential transitions globally available for selection in a particular context of interaction while, locally, at each DAG node (Interaction Control State, ICS), the potential constructions and transitions are expressed by LOFT descriptions that obey tree axiomatisation principles. As DS is a model-theoretic formalism (Pullum and Scholz, 2001), all the inferential activity modelling incremental parsing/production is defined at the level of con-

straints articulated through the vocabulary of the relevant logics. The transformation of such PDL and LOFT descriptions is accomplished via general and lexicon-driven mappings expressed as patterns of established and relatively stable sequences of basic actions (*macros*). Such macros effect the progressive projection of content, i.e., further opportunities for action, for emergent tree-structured trajectories following the time-linear order of presentation of a linguistic string. The tree-structured paths traversed by means of the LOFT modal operators, reflect the structuring of physical and cognitive actions that take place during linguistic processing. Some of the outcomes of such actions can be reified as predicate-argument structures by assuming an external, God's eye, non-modal-logic point of view that abstracts from the process of inducing and traversing such structures. This is a useful and often needed perspective, both for theory construction and for practical human purposes like teaching, metalinguistic reflection and many others but, in our view, it should not obscure the most basic subpersonal level of processing from which it emerges.

Bringing this framework to bear on current views within REEC, Gregoromichelaki et al. (2019) claim that DS is compatible with a view of NLs as activities, "languaging", rather than manipulation of knowledge structures that define arbitrary mappings from sound to propositional symbolic representations. This is because DS articulates state-transition mechanisms relative to an ever-evolving context without needing to attribute finalised and fixed contents to sentence strings. Crucial in this perspective is incorporating in the formal framework the social normativity expressed by the grammar. The native incrementality and action-orientation of DS, as demonstrated by Kempson et al. (2016) amongst others, is well-suited to implement the fine-grained modelling of conversational dialogue dynamics, in particular the wholly fluent manner in which co-participants in a dialogue switch roles, share utterance responsibility, or effect repair.

Against the non-representational claims of (Gregoromichelaki et al., 2019), one might argue that despite adopting the relatively broad concept of *affordances*, following Bruineberg et al. (2018), with all macros (lexical and general) seen as manifest affordances, DS necessarily needs to also invoke representations, thus conflicting with fundamental REEC assumptions. This is because syntax appears to be defined as tree and graph development procedures in a manner similar to generative-enumerative frameworks like CCG and Minimalism (Pullum and Scholz, 2001). Indeed, among other apparent representational features of DS mechanisms, in particular, it has been argued in major support of the framework that the abandonment of universal constraints on structure urged by some (Christiansen and Chater, 2008; Evans and Levinson, 2009; Bybee, 2010; Haspelmath, 2020) can be reversed by the shift to a dynamical system that operates with partial trees and their incremental introduction. This is because universal structural constraints can be shown to hold due to the inferential principles of LOFT, the constraint articulation basis of describing tree graph transitions in DS. In particular, it is argued (Cann et al. (2005); Kempson et al. (2016) a.o) that all licensed partial tree-shaped trajectories are subject to a universal structural constraint prohibiting more than one token of any fully or partially individuated node at any one time. This principle is demonstrated to hold across various structures and languages. However, we will argue here that this constraint is not only not specific to some presumed "language faculty", but that it is more general even than human cognitive capacities, being grounded within the core physical laws underlying the behaviour of complex systems. With this reducibility of a putative NL-exclusive structure-inducing constraint to wholly general principles, we will argue that indeed defining NL capacities in dynamic terms fits the REEC perspective in which all aspects of cognition are seen as grounded in action without essential invocation of brain-internal mental representations.

2 Structure-inducing constraints on path traversals: tree structures

The set of affordances in a context are perceived differentially by each agent or group of agents depending on their level of attunement, their skills and abilities, regarding the relevant practices that constitute the source of such affordances. Available affordances will also be partitioned and ranked depending on the concerns and purposes of the agents involved (agent-relevant affordances are called 'solicitations', Rietveld et al., 2018; Bruineberg et al., 2018). Such demarcated so-called 'fields of affordances' are represented in DS by the

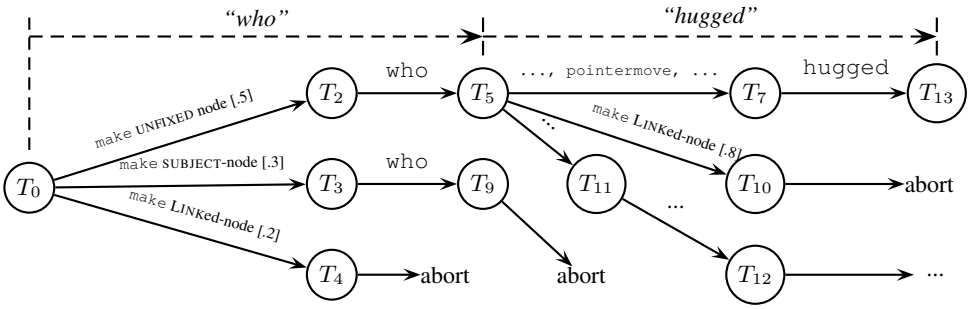

Figure 1: DAG: *Who hugged*

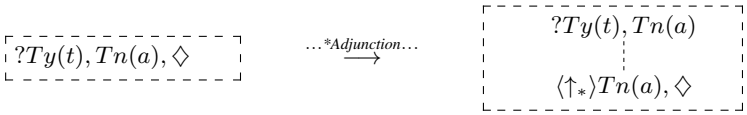

Figure 2: Introducing an "unfixed" node

Figure 3: *who*-induced actions

time-linear unfolding of the DAG during conversational interaction, see Fig. 1 (see also Sato, 2011; Eshghi et al., 2013; Hough and Purver, 2012).[1]

Focussing attention at the local level of DAG nodes (ICSs), the first step is to consider the mapping between a string of words, in DS, a sequence of triggers for macros, and the DAG-transformations that it induces. The specialised PDL backbone of DS operates by means of prediction of available open paths of development constrained by so-called *requirements* (these are indicated by ? appearing in front of any available grammatical action). The constraints thus induced by the grammar (and other contextual factors) define a range of goals for the next steps of processing. Agents attuned to the grammatical practices available in a particular context can pursue the most relevant goal defined in this context guided by a process of affordance competition (Cisek and Thura, 2019). For example, a potential starting point of such a process can be a node state as displayed in Fig 2. Here we find the indicator of the current focus of attention, the pointer ◇, and a prediction reflecting the expectation that a proposition ($?Ty(t)$) can be developed. This expectation will lead to many alternative predicted paths of achieving this development that can be displayed as shown in Fig 1. In Fig 2 we pursue one of those paths, the topmost path in the DAG, which is an option made available by the English grammar: a macro called **Adjunction* can introduce a radically structurally underspecified ("unfixed") node predicted to be needed to accommodate the processing of a content-underspecified element like *who* as seen in Fig 3. The latter processed first in a sentence can end up in multiple argument positions eventually so its contribution, a metavariable notated as **WH**, needs to be held in memory until a suitable place is found for it later in the process. Therefore, the identification of the node that accommodates the macro associated with *who* does not specify immediate dominance relations with respect to the root node, as shown in the illustration, Fig. 2-3. This is indicated by the dashed line. The underspecified relation is expressed via the modal operator $\langle\uparrow\rangle$ appearing in front of the root node identifier, $Tn(a)$ specifying that the relation between the two nodes is one of (non-immediate) dominance[2].

As can be seen in the topmost path of the DAG, eventually the verb *hug* will be processed and its subject requirement will enforce the contribution of *who* to be specified as such. In DS this means that the unfixed node will now become fully specified with respect to all dominance relations. Once such a DAG path has been success-

[1] In order to simplify presentation, the available macros have been significantly condensed and schematically mentioned through the more central effects they induce; ellipsis (...) indicates that multiple steps have been omitted as they have been judged as irrelevant to the point we wish to make.

[2] $\langle\uparrow\rangle$ is the modal operator expressing an immediate dominance relation, $\langle\uparrow_*\rangle$ is the operator which, using the Kleene * operator, expresses the weaker dominance relation.

fully traversed, the state reached will record a tree-structured topology of information with no words left to be parsed/generated any more (see (Kempson et al., 2001, 2016; Hough, 2015) for details).

The constraint on tree development which is then proposed for all stages of every DS process is that there be only one copy of any node at a particular DAG path. This is a general constraint which follows from the logic of partial tree construction: each node in a partial tree at any stage of the development process has a unique identity with respect to the other nodes. This restriction applies equally to *structurally underspecified* nodes whose precise position is yet to be established: any information regarding the state identified as that unfixed node that might be introduced at different stages of processing is accumulated to constrain that particular node. And until its tree-relative identification has been updated to a more specific one no other node can claim a similarly underspecified identification. The effect is a "no-copy" principle for any node-to-node transition.

2.1 Syntactic puzzles resolved

Since its first introduction, this novel dynamic of processing incorporating parsing and generation under the same formalism, hence intrinsically a dialogue model (Eshghi et al., 2015), was first applied to solve a number of puzzles concerning syntactic and semantic/pragmatic phenomena as well as their interaction. Such inclusivity, in our view, is justified by the domain-generality of the constraints proposed, which conventional frameworks need to either set aside or address partially by proposing additional auxiliary hypotheses and language-particular stipulations, substantially weakening the explanatory force of the approach.

The first such puzzle is very free word ordering, common across languages, which is generally problematic, as the default presumption of a VP constituent does not apply in these languages. Most striking is the verb-final language pattern, by report the most common language pattern (Dryer, 2013). This is a phenomenon which at first sight appears problematic for the DS framework as well. In particular, in so far as these languages provide sequences of noun phrases before some finally placed verb, they often apparently allow all possible orderings of the arguments for that verb. So they would seem to present immediate problems for the commitment of incrementality taken by the DS framework, as they would seem to warrant the multiple introduction of unfixed nodes. Upon such an analysis, such nodes would all need to be distinct, all free to occur in any order, all in some sense having to wait for the verb in final position from which the structure can be projected to consolidate their position in that emergent structure (see (Pritchett, 1992) and others following):

(1) *supai-ni* *syorui-o*
the spy$_{DAT}$ the document$_{ACC}$
zyaanarisuto-ga *watasita*
the journalist$_{NOM}$ handed [Japanese]
The journalist handed the document to the spy

But this is precisely what the "no more than one" such characterised node at a time restriction precludes. However, as argued in (Kempson and Kiaer, 2010), there is a simple solution to this challenge. For example, in Japanese and many other languages, it is the case-suffix whose processing determines the appropriate precisification of the tree relation. So case morphology, under this view, has a crucial processing and semantic purpose, the introduction and restriction of further possibilities of action, instead of just being seen as a feature-matching reflex of some overarching syntactic structure.

The process of structuring the emergent DAG is then one of introducing an unfixed node accommodating the contribution of the nominal content, with an immediate update step enriching that structure to provide a node commensurate with what the case-marking dictates, thereby enabling the introduction again of an unfixed node, without any duplication at any particular stage of a tree-node identification. An entirely similar analysis applies to Korean (Kiaer, 2007). This approach is notably confirmed by experimental work establishing the incremental nature of Japanese sentence processing (Witzel and Witzel, 2016).[3]

2.2 Morpho-syntactic puzzles resolved

This dynamic applies with equal force in the morpho-syntax arena, indeed as expected given that lexical processing capacities are taken to be due to routinisations (macros) established over an extended period. The very same pattern of analysis is taken to apply to the puzzle facing analyses of clitic clustering, where arbitrary lexical gaps in the paradigm are attested. A well-known such case

[3] See also (Kiaer, 2007, 2014) for extensive discussion and experimental evidence from Korean.

is the Person Case Constraint (PCC; Perlmutter, 1970; Bonet i Alsina, 1991), which, in its standard variant, states that a dative clitic cannot co-occur with a 1st/2nd person accusative clitic:

(2) *Le* *me* *ha* *dado*
him$_{CL-DAT}$ me$_{CL}$ has given
'S/He has given me to him.' [Spanish]

The restriction on unfixed nodes, namely the fact that no more than one treenode with the same address is possible, gives us a natural explanation of the PCC effects. The explanation is strikingly straightforward from a DS perspective: dative clitics are underspecified in general. In Romance, this underspecified nature of the dative can be traced back to Latin, where dative marking is notoriously ambiguous (van Hoeke, 1996), this a general problem with dative case-labelling. In and of itself, that is, dative does not determine a fixed hierarchical position in the structure. Similar diachronic considerations also apply for other languages that show the same PCC effects, e.g. Greek (Chatzikyriakidis, 2010; Chatzikyriakidis and Kempson, 2011). Given this underspecification of the dative, the plausible assumption to make is that dative clitics are processed on an unfixed node, so as to allow variant interpretations of the dative. Furthermore, 1st and 2nd person accusative clitics in Spanish and many other Romance languages are syncretized with the dative, i.e. the same morphological form is used for both the 1st and 2nd person accusative, as well as the 1st and 2nd person dative clitics. Thus, 1st and 2nd person accusative clitics can also be taken as underspecified and processed on an unfixed node too. Now, given the "no copy" constraint, any combination of a dative clitic with a 1st or 2nd person accusative clitic will be disallowed as two unfixed nodes cannot be introduced at a single stage of processing and, as a result, the incompatible information from the two types of clitics on a single node will lead to anomaly. 3rd person accusative clitics, to the contrary, are not syncretized with the dative and, furthermore, always interpreted as direct objects. In DS terms, this means that they are processed within a fully specified structure, rather than on an unfixed node. Thus, the "no copy" constraint does not interfere with the processing of combinations of a dative and a 3rd person accusative clitic. There are a number of variants of the PCC, e.g. the weak PCC version, which allows combinations of 1st and 2nd person pronoun clitics, but this variability has been shown to be afforded by the formal machinery of the system as well (Chatzikyriakidis and Kempson, 2011).

The significance of these results, here of syntactic and morphosyntactic type, is that these are observable low-level NL-particular facts apparently warranting complex and unavoidable stipulation in distinct components of the grammar. Current individualistic linguistic theories justify this split on the basis of notions like competence-performance, modularity (Fodor, 1983), and Marrian computational vs algorithmic level distinctions (Marr, 1982; Steedman, 2000; Kobele, 2012). Within the DS framework, in contrast, these patterns are seen to fall out in virtue of modelling syntax as the progressive structuring of the landscape of affordances for interpretation and production in everyday human interaction. Such normative morphosyntactic constraints become historically sedimented into practices routinising the most frequently taken up processing paths (macros), whether as a parser or a producer. Being normative constraints, such macros are necessarily independent from individual NL users and they are potentially inadequately grasped by the skill level (attunement, 'abilities') and concerns of individual agents. Hence the potential for innovation and change as well as flexibility and adaptability. Nevertheless, the availability of such macros in a practice-sharing 'form of life' allows agent coordination due to their operation as joint relevant affordances ('solicitations').

3 NL affordance competition

There is a range of approaches within REEC usually grounded within dynamical systems models of socio-cognitive phenomena (Chemero, 2009). Most of those espouse non-representational accounts of perception and action, so-called "lower cognition" or "basic minds". However, even advocates of radical enactive perspectives stop short from extending this approach to "higher order" cognition, especially language (see e.g. Clark, 2016; Hutto and Myin, 2012). Moreover, even accounts that aim to develop NL models compatible with dynamical and complex systems approaches like connectionism, due to the individualistic perspective they adopt, suggest that neural network implementations strengthen the competence/performance distinction and support the emergent nature of symbolic representations (Prince and Smolensky, 1997). Against this view,

REEC researchers (Rietveld et al., 2018; Bruineberg et al., 2018; Paolo et al., 2018) aim to integrate all levels of cognitive activity within the enactive approach. DS sides with the latter view in that the constraints defined through the logic underlying the framework constitute additional affordances available in the sociomaterial environment of human interactions and are not confined within individual brain structures. DS constraints concern the *process* of comprehension/production in a social context as aspects of general perception/action mechanisms defined via sensorimotor loops that do not necessarily engage representational constructs (even though reification of such subprocesses and representational abstraction is also considered possible). Under such a view, all grammatical dependencies are able to function as word-by-word incremental coordinating devices, i.e., affordances, see, e.g. (3) - (4) for either interlocutor (Gregoromichelaki et al., 2011, 2013a). This is possible and efficient irrespective of whether or not coherent units like standard representational constructs like 'sentences' or 'propositions' are ever derived or not:

(3) Hester: It's for me.
Mrs Elton: And Mr Page?
Hester: is not my husband. [The Deep Blue Sea (film)]

(4) A: SOMEONE is keen
B: says the man who slept here all night
[BBC Transcripts *A-Word*]

Instead of propositional knowledge of rules and manipulation of representations, the abilities of being able to interact through such grammatical constraints could then be characterised as subpersonal mechanisms allowing access to a normative landscape of affordances that induces predictive goals (solicitations) to be fulfilled by either interlocutor in the very next steps which they will be taking. The skills required to take advantage of solicitations in such a context does not presuppose any 'rational' high-order individualistic inference, standardly taken to be the basis of all successful human communication(Clark (1996); Sperber and Wilson (1995) and many others). Instead, the task of selecting appropriate actions is taken over by affordance competition (Cisek and Thura, 2019; Anderson, 2014; Rietveld et al., 2018). However, this presupposes that not only does the grammar incorporate processing features like incrementality and predictivity but also that the grammar provides a shared "workspace" (Kempen, 2014) for both production and comprehension to operate and interact (Gregoromichelaki et al., 2013b).

In addition, non-linguistic practices need to be integrated with linguistic actions to contribute their qualitatively identical types of constraints (Gregoromichelaki, 2018). Evidence that morphosyntax directly interacts with embodied situational affordances of every day action comes from elliptical constructions. For example, in case-rich languages such as German and Greek, elliptical fragments necessarily display the form suitable to what might have been a complete sentence formulated in response, even when there is no obvious antecedent of a verbal sentential form– in the German example in (5) the accusative form *den Arzt* seamlessly blends with other situational affordances to constrain future action to the effect that someone should call a doctor:

(5) *A and B see a woman lying on the floor:*
A to B: Schnell, den Arzt/#der Arzt
Quick, the doctor$_{ACC}$*/#the doctor*$_{NOM}$

The question that then remains is how to think of alleged sui-generis properties of NL morphosyntax that have been adduced as arguments for claims like "the autonomy of syntax" hypothesis. Within DS, this question is pertinent regarding the status claimed universal NL constraints like the "no-copy" restriction. While this remains an issue for much further development, we suggest that, within a domain-general framework like DS, there are grounds for seeing this restriction as a general control property of socio-cognitive coordination systems (control in the cybernetic sense of 'regulation', e.g. Bickhard (2009); Carver and Scheier (2012)) and, therefore, indeed a general property of physical systems.

Anderson (2014), like DS, attributes to individual brain mechanisms the role of action control functions ('abilities') via perception/action feedback loops without necessary representational mediation. The brain is modelled as a connectionist network inspired by (Smolensky, 1986)'s architecture but without the individualistic representational interpretation. The state transitions and attractor landscapes of this network control the interaction of the individual and the environment without presuming that the brain constructs a model of the world it interacts with. Like REEC's view of skills, abilities, and dispositions, the contribution of the individual brain is seen as complementary to the roles of the whole body and the envi-

ronment and, on its own, in no way able to sustain conceptually-transparent reactions to the environment. Accordingly, the states that the network passes through are not assigned representational contents but are individuated by their responsiveness to particular inputs and behaviours that they enable. As part of the control of behavior architecture, different patterns of activation at each state track the convergence of the control mechanism towards a particular action.

What is important for us here is that affordance competition in Anderson's interpretation is implemented by the fact that neural patterns of activation might reflect simultaneously multiple partially-activated options before final convergence to the selected action goal. However, at the update stage of convergence (i.e. when a "decision" has been reached), the partial specifications of multiple action goals will be necessarily eliminated if their full activation patterns are incompatible, i.e., if they require the same brain regions. We suggest that the 'no-copy' constraint on LOFT tree-path traversals is of the same type and aetiology: LOFT imposes a restricted architectural capacity to accommodate selected action opportunities. For example, an 'unfixed node' state can accommodate multiple affordances, in the case of Greek clitics, gender, person, number specifications, etc. However, any treenode annotations on the DAG, including unfixed nodes, is the outcome of the convergence of affordance competition. For this reason, annotation of action goals is the equivalent of fully-specified activation patterns which cannot occupy overlapping brain regions. Similarly, in DS, a node can only accommodate compatible selections of multiple macros as requirements for further update. If incompatible macros come to be associated with the same node the result will be anomaly because there is no possibility of pursuing the action paths indicated as subgoals from that specific starting point. So in both cases, affordance competition is the underlying cause for action selection, action control and limitation with NL constraints being subsumed under an overall behaviour-guidance and general systems-control architecture.

In closing, we note that, besides morphosyntax, a further integral task in this program is capturing the enormous range of interpretations which words display, a challenge often treated as peripheral. Current work on the adoption of a vector-based semantics for the affordances words provide is ongoing, with the goal of modelling the pervasive variability of word meaning. This approach builds on previous work on compositional distributional semantics for pregroup grammars and the Lambek Calculus (Coecke et al., 2010, 2013), and for Combinatory Categorial Grammar (CCG) (Maillard et al., 2014; Moot, 2018). There is current work in this area, where distributional meanings of words are combined with their grammatical types, albeit more informally (e.g. Baroni and Zamparelli (2010)), but these do not consider an incremental setting with underspecified nodes in the grammatical construction, a challenge which our program addresses. Purver et al. (forthcoming) suggest two distributional counterparts to underspecificational notions, and present experimental results regarding affordance competition that results in optimal choice in the disambiguation task.

4 Conclusion

The shift of emphasis from static structural generalisations to actions is central here. The goal is not to generate a sentence structure or proposition as such: it is to promote progressive context-updates yielding further affordances guided by the various practices constraining and enabling the actions of the interlocutors. Given the domain-generality of the DS architecture, constraints arising from non-verbal practices blend seamlessly with morpho-syntactic and semantic constraints. Context-updates thus follow constrained trajectories modelled as graph-transitions of restricted formats, with an intermediate level of tree-structured paths that account for morphosyntactic constraints in an incremental manner due to various types of licensed underspecification. Due to the initial availability of various options for update and subsequent incremental culling as constraints accumulate from various sources and at various stages, a process of affordance competition emerges as the action selection mechanism. It is notable that this mechanism applies across sources of constraints bridging the levels of both "lower-" and "high-level" cognition.

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